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(54) **SYSTEMS AND METHODS FOR DESIGNING EXPERIMENTS**

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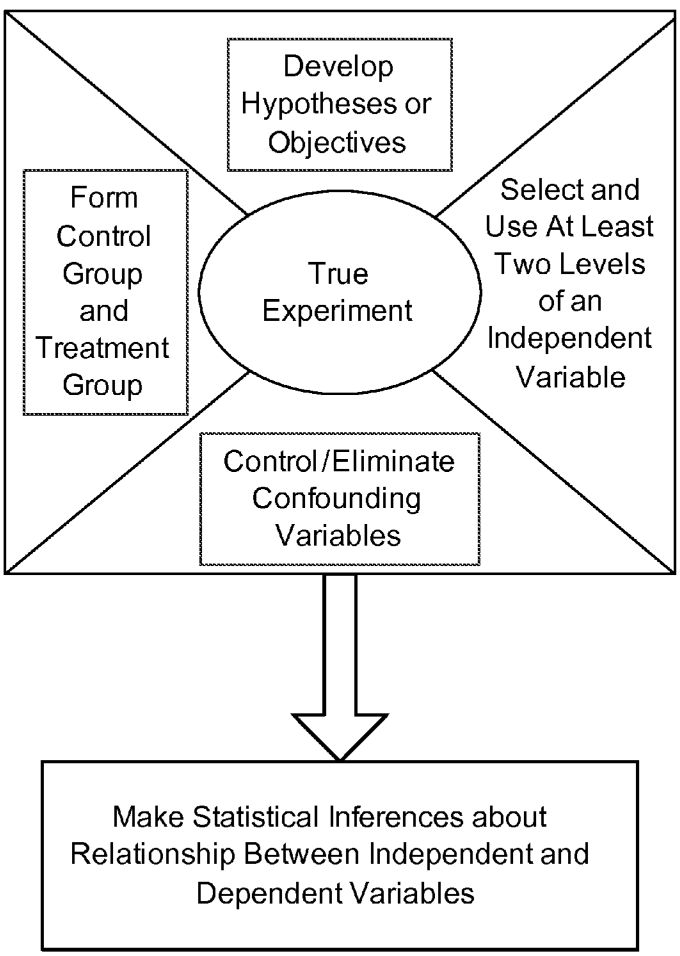
(57) **ABSTRACT**

Methods and systems for designing an experiment using a computer to determine whether the experiment is a true experiment are described. These approaches allow a user who is unsophisticated in the complexities of true experimental design to design and deploy an experiment that produces substantially confound-free results and can be used to determine and quantify any causal relationship between independent and dependent variables. The computer may select one or more independent and/or dependent variables of the experiment or may assist the user in selection of independent and/or dependent variables. Formation of control and treatment groups, randomization and/or blocking to reduce the effects of confounding variables may be performed by the computer with or without input from the user.



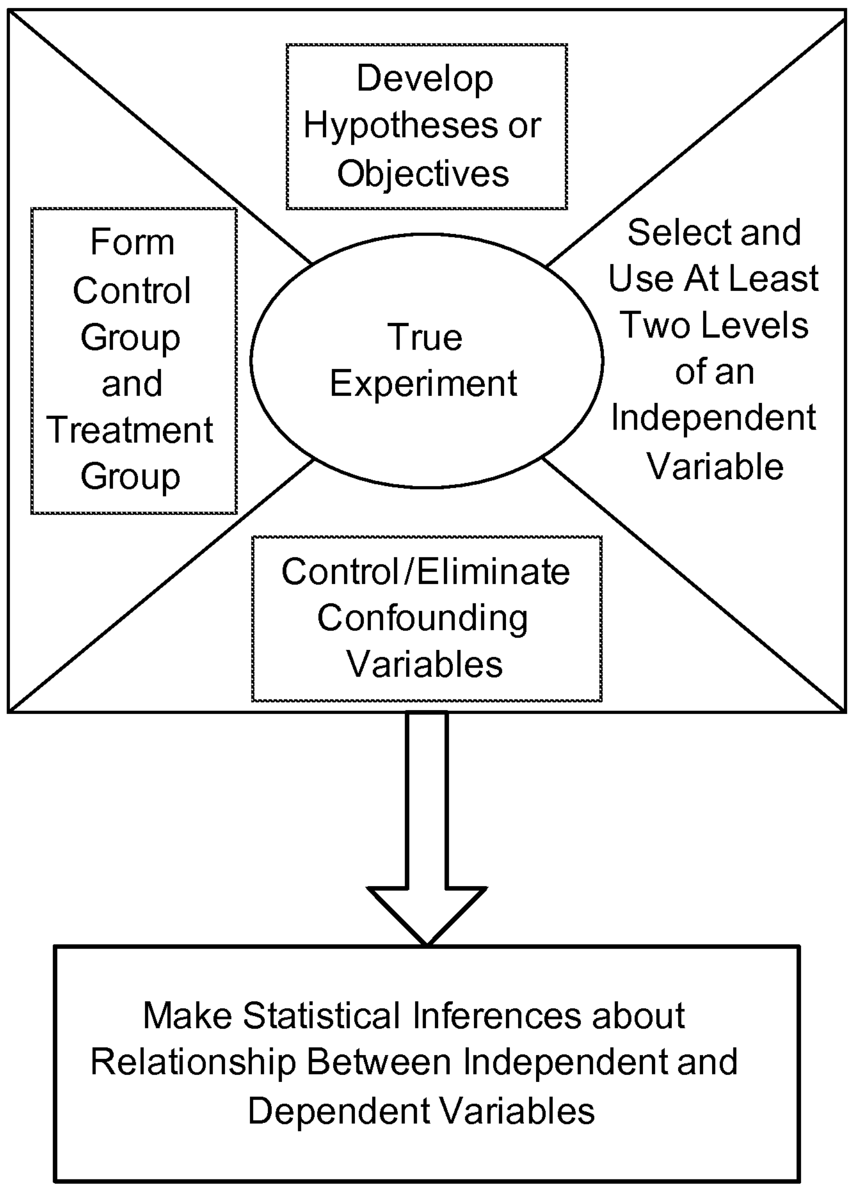

Develop Hypotheses or Objectives
Form Control Group and Treatment Group
True Experiment
Select and Use At Least Two Levels of an Independent Variable
Control/Eliminate Confounding Variables
Make Statistical Inferences about Relationship Between Independent and Dependent Variables

FIG. 1

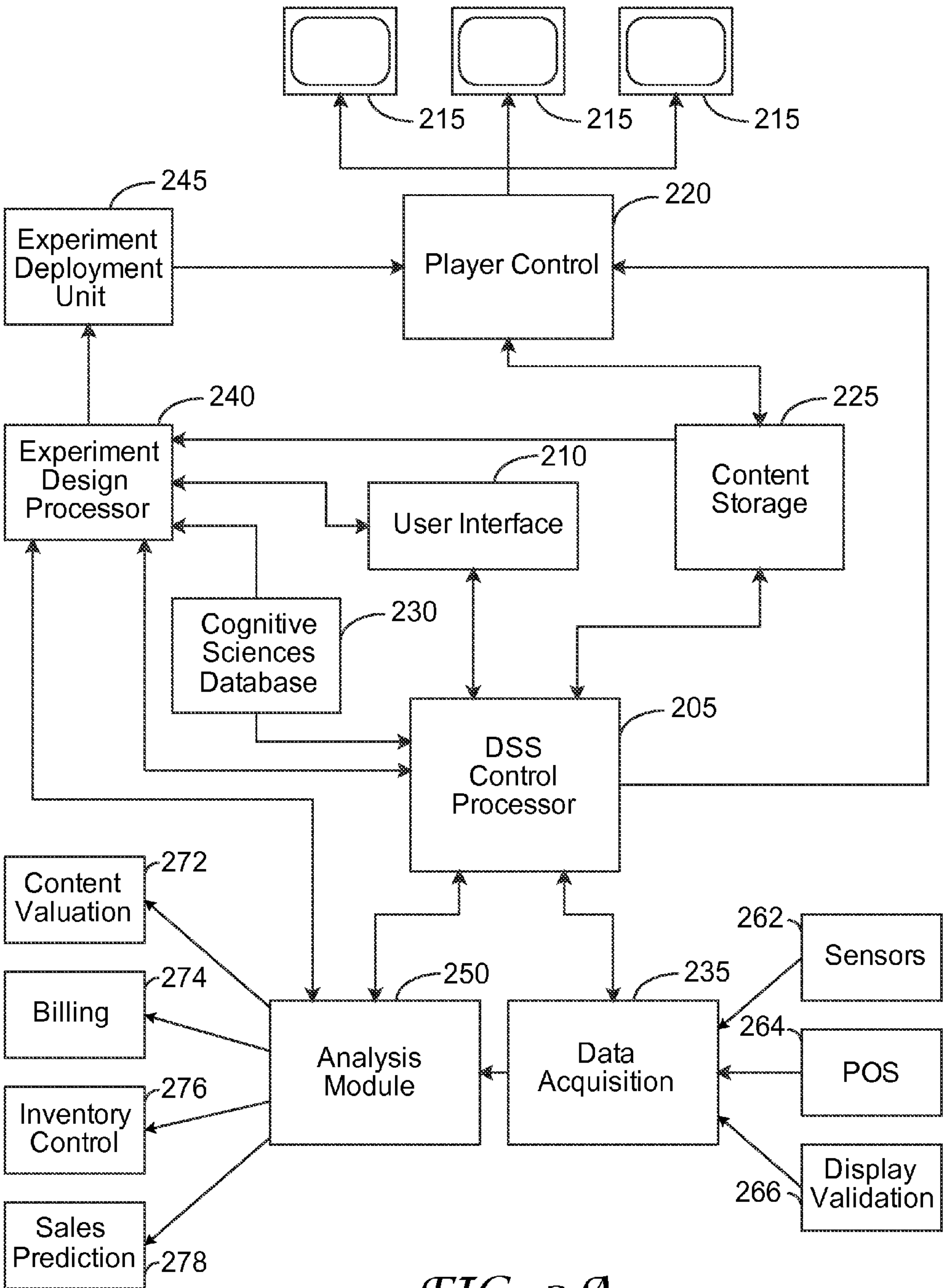

215
215
215
245
Experiment Deployment Unit
220
Player Control
240
Experiment Design Processor
210
User Interface
225
Content Storage
Cognitive Sciences Database
230
DSS Control Processor
205
Content Valuation
272
Billing
274
Inventory Control
276
Sales Prediction
278
Analysis Module
250
Data Acquisition
235
Sensors
262
POS
264
Display Validation
266

FIG. 2A

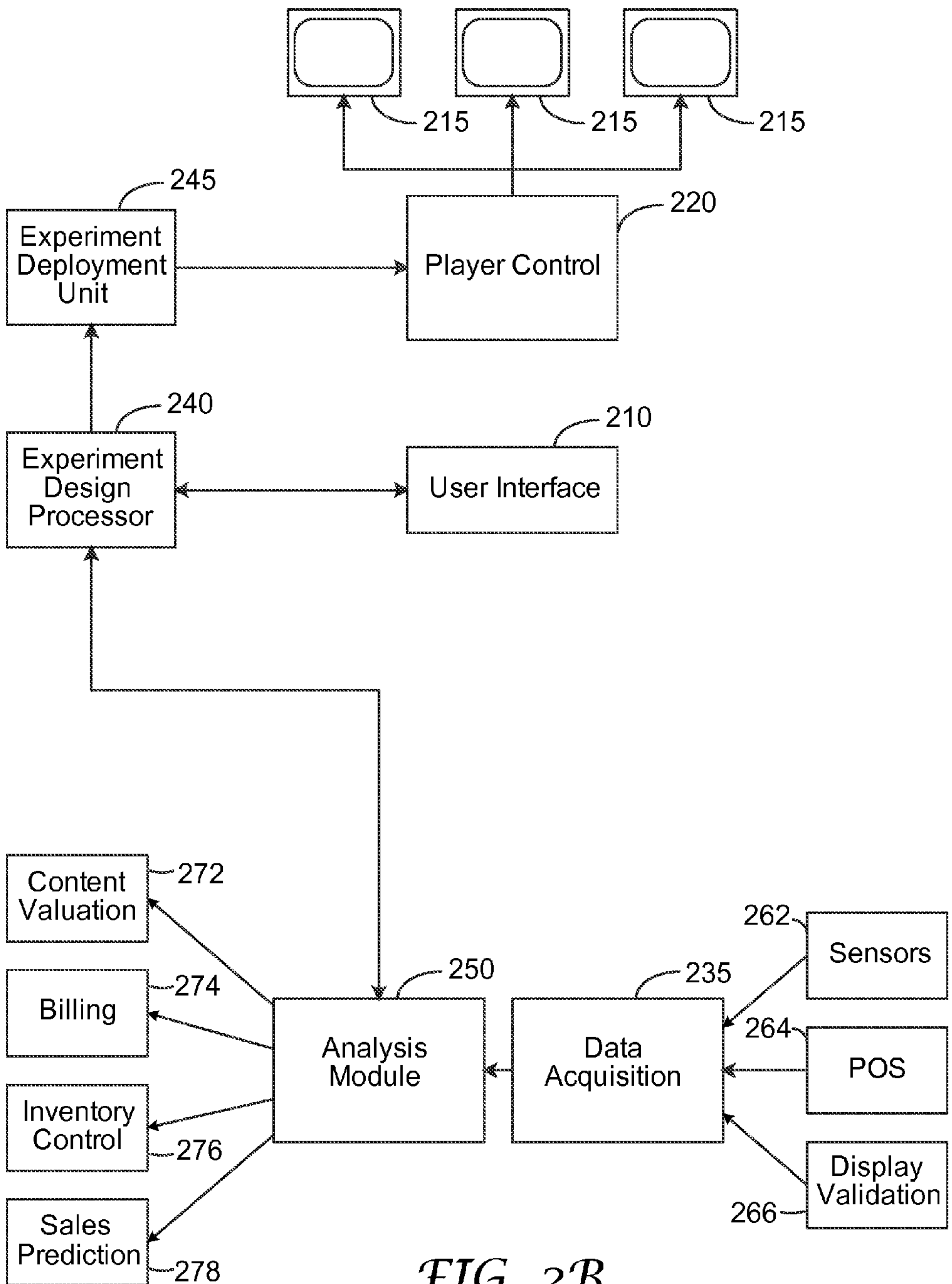

215
215
215
245
Experiment Deployment Unit
Player Control
220
240
Experiment Design Processor
210
User Interface
Content Valuation
272
Billing
274
Inventory Control
276
Sales Prediction
278
250
Analysis Module
235
Data Acquisition
262
Sensors
264
POS
Display Validation
266

FIG. 2B

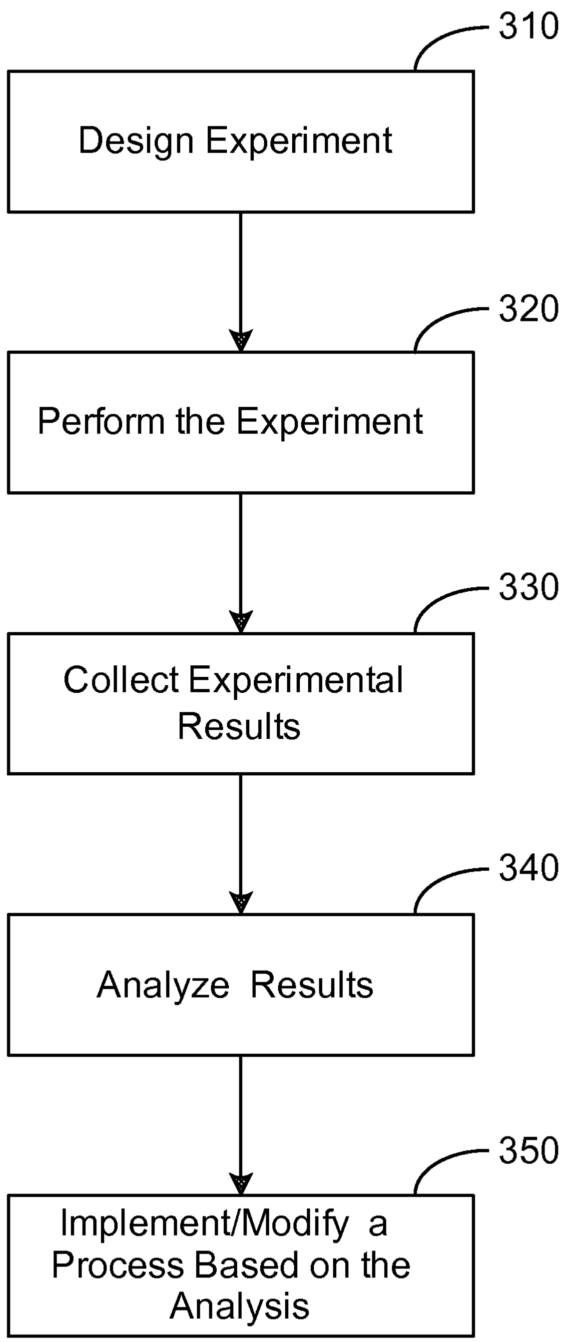
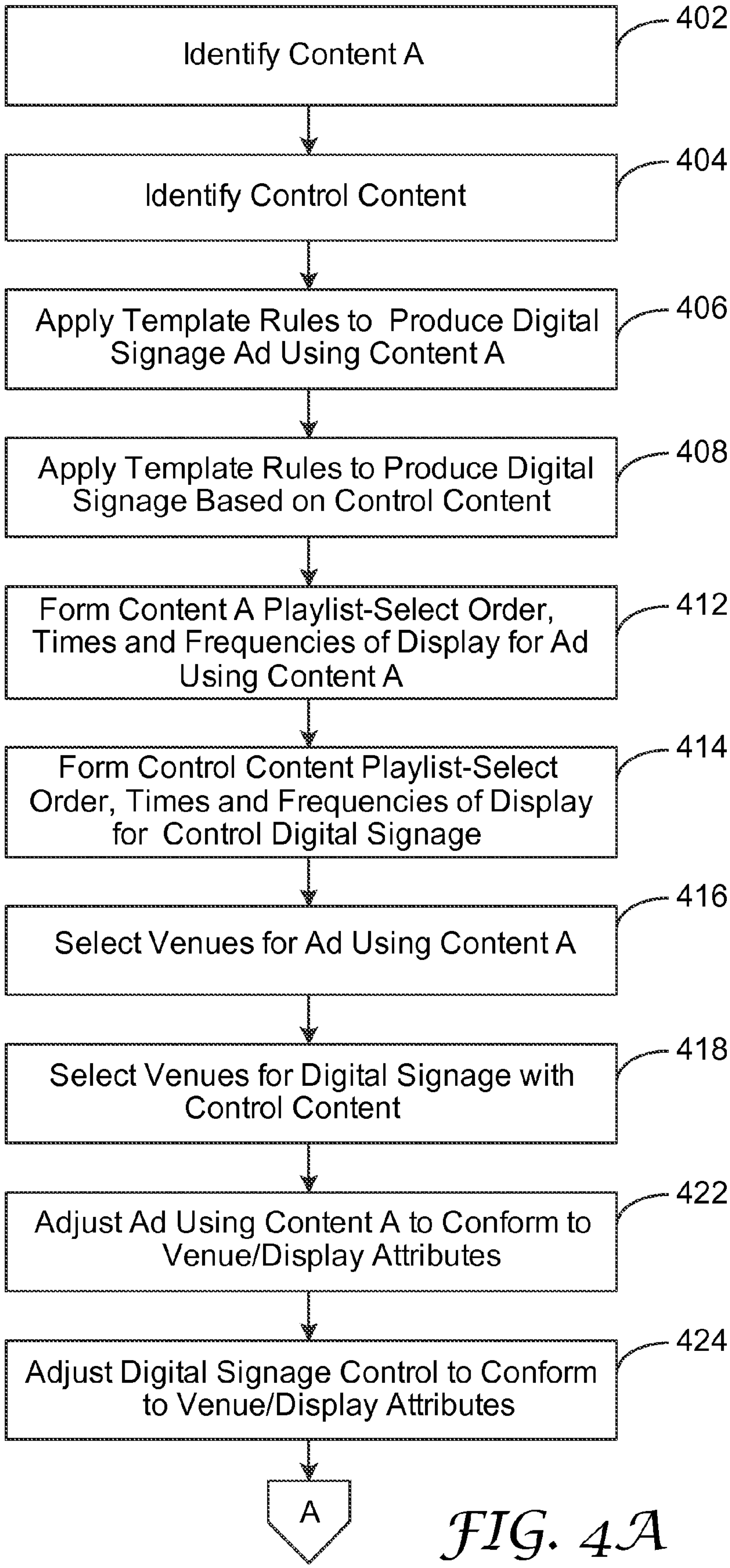

310
Design Experiment
320
Perform the Experiment
330
Collect Experimental Results
340
Analyze Results
350
Implement/Modify a Process Based on the Analysis

FIG. 3



Identify Content A
402
Identify Control Content
404
Apply Template Rules to Produce Digital Signage Ad Using Content A
406
Apply Template Rules to Produce Digital Signage Based on Control Content
408
Form Content A Playlist-Select Order, Times and Frequencies of Display for Ad Using Content A
412
Form Control Content Playlist-Select Order, Times and Frequencies of Display for Control Digital Signage
414
Select Venues for Ad Using Content A
416
Select Venues for Digital Signage with Control Content
418
Adjust Ad Using Content A to Conform to Venue/Display Attributes
422
Adjust Digital Signage Control to Conform to Venue/Display Attributes
424
A

FIG. 4A

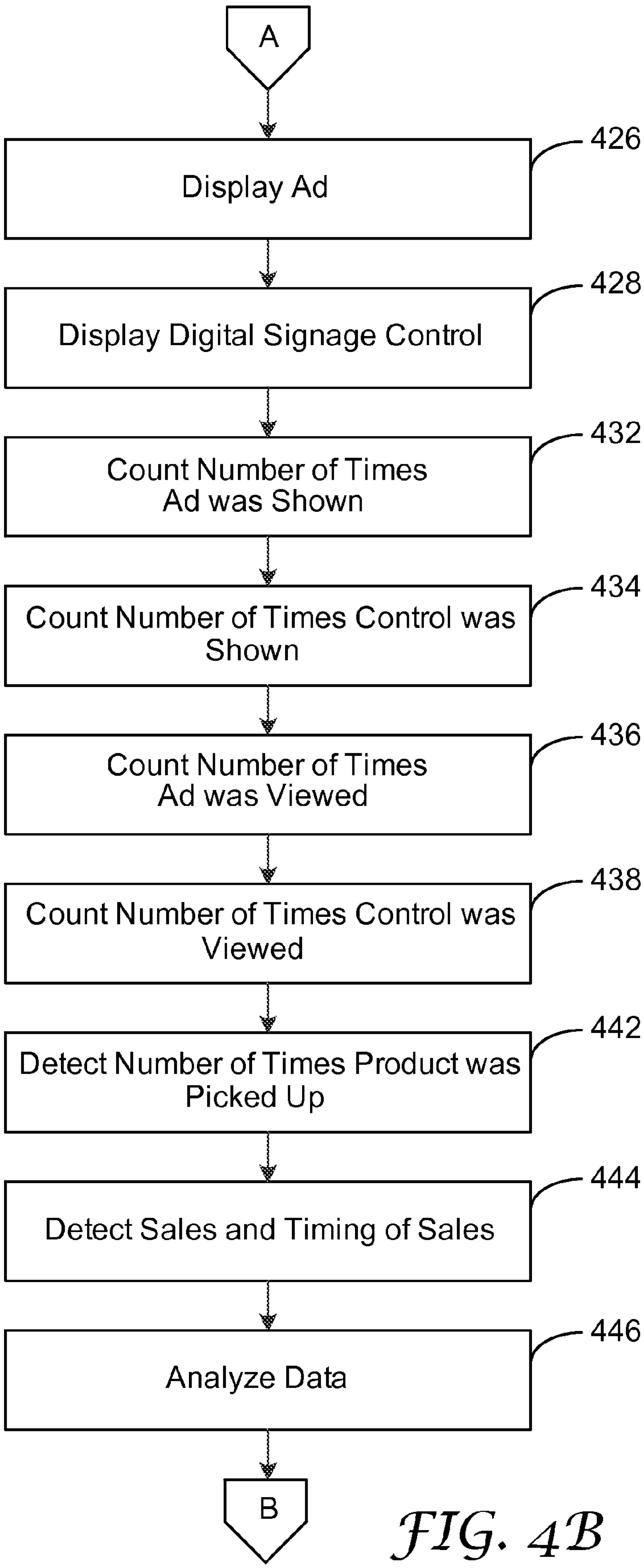

A
426
Display Ad
428
Display Digital Signage Control
432
Count Number of Times Ad was Shown
434
Count Number of Times Control was Shown
436
Count Number of Times Ad was Viewed
438
Count Number of Times Control was Viewed
442
Detect Number of Times Product was Picked Up
444
Detect Sales and Timing of Sales
446
Analyze Data
B

FIG. 4B

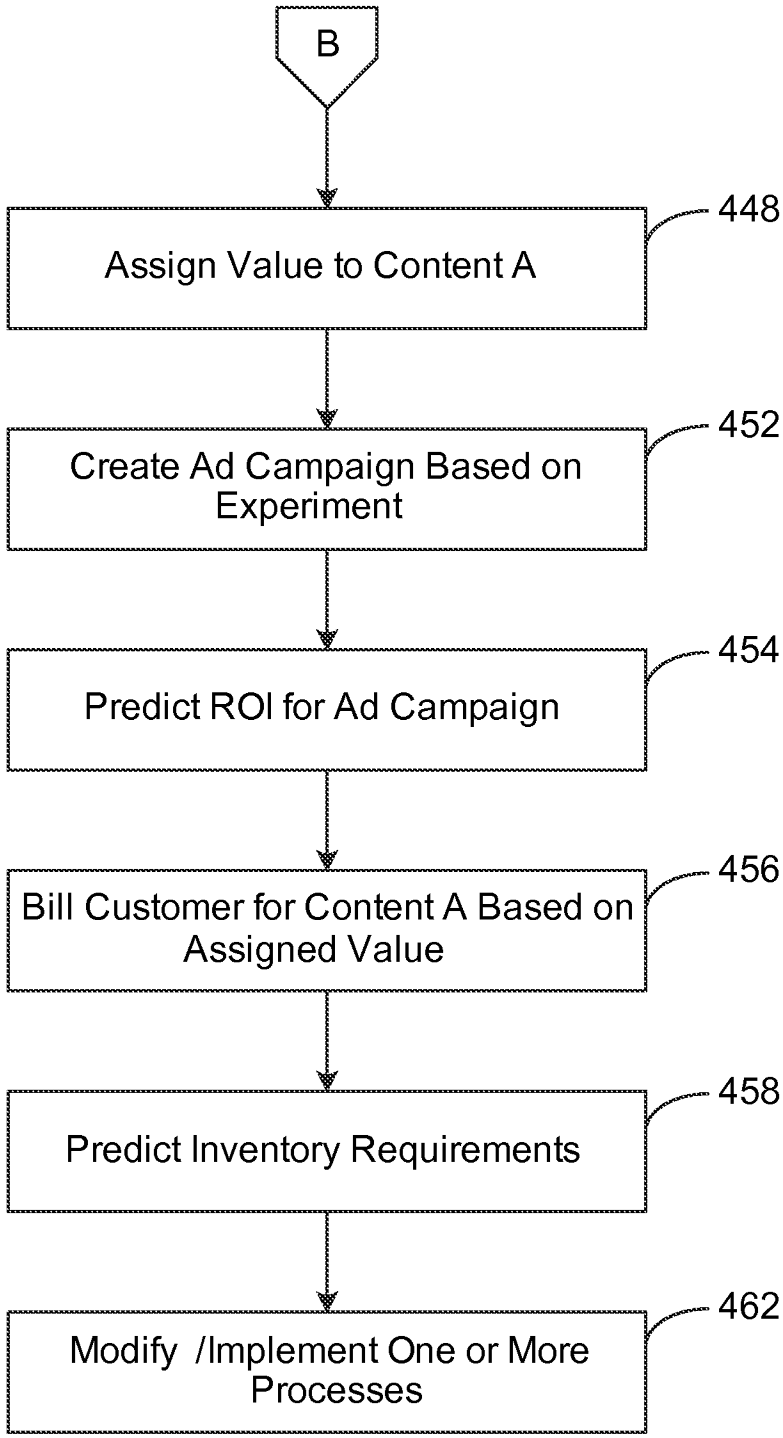

B
448
Assign Value to Content A
452
Create Ad Campaign Based on Experiment
454
Predict ROI for Ad Campaign
456
Bill Customer for Content A Based on Assigned Value
458
Predict Inventory Requirements
462
Modify /Implement One or More Processes

FIG. 4C

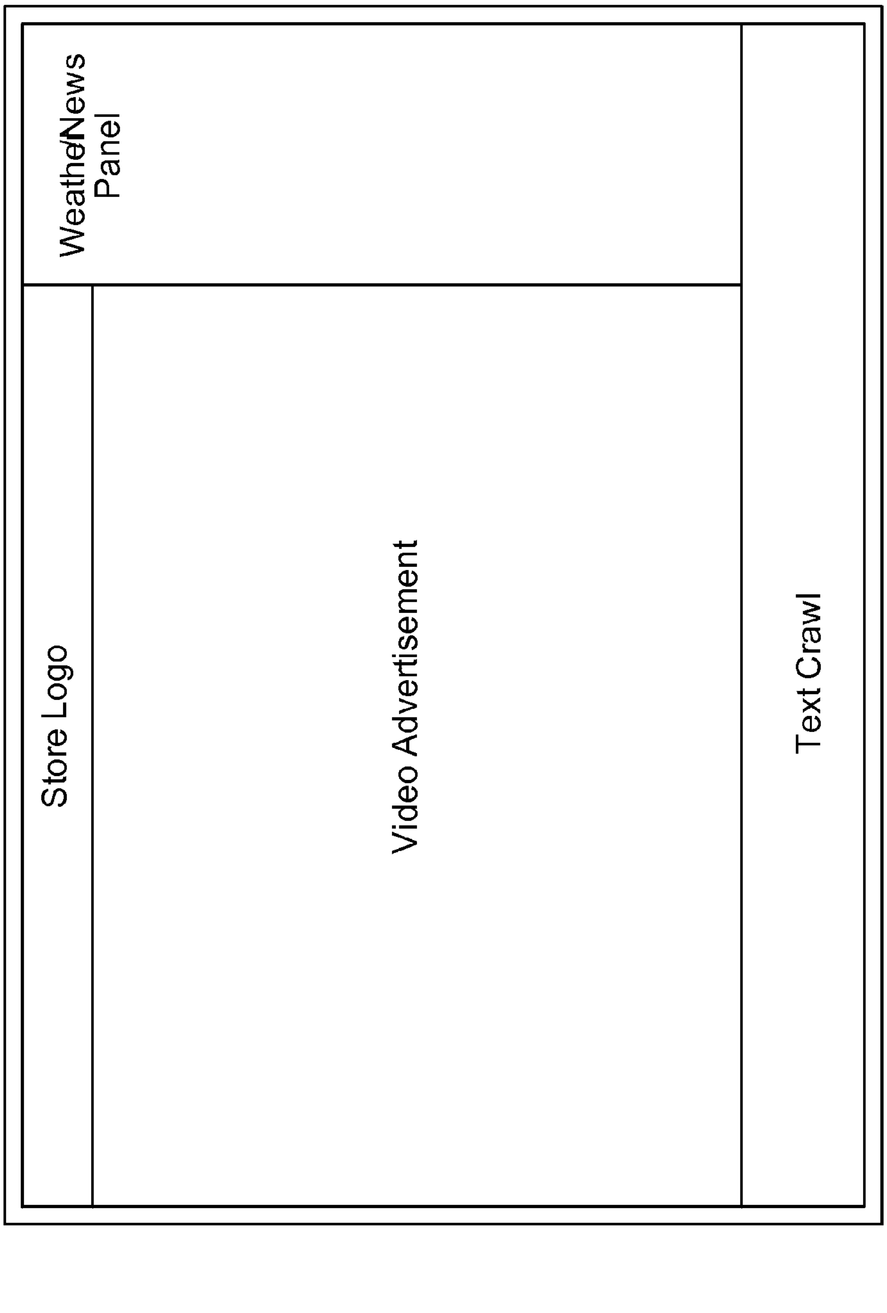

Weather/News Panel
Store Logo
Video Advertisement
Text Crawl

FIG. 5

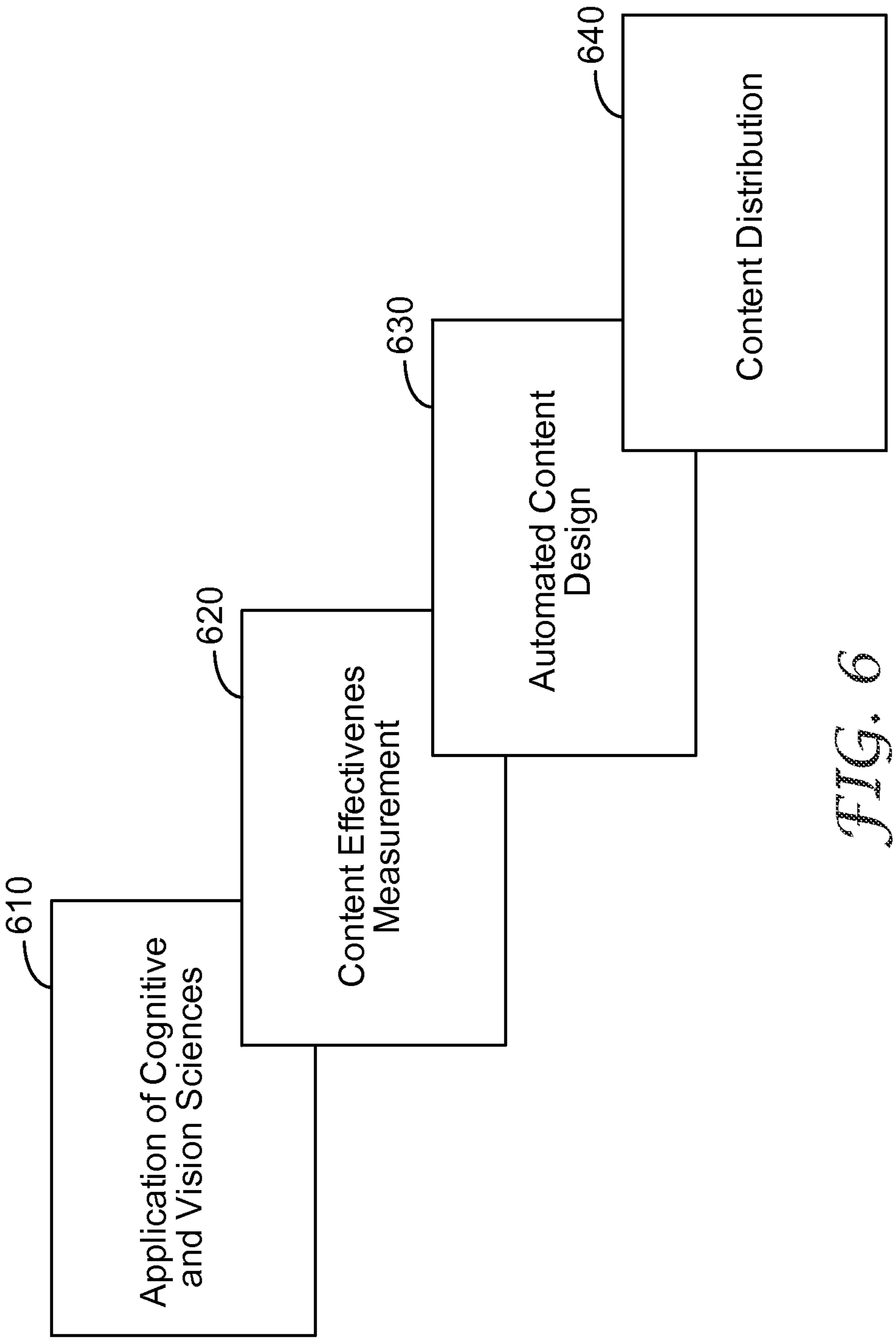

610
Application of Cognitive and Vision Sciences
620
Content Effectivenes Measurement
630
Automated Content Design
640
Content Distribution

FIG. 6

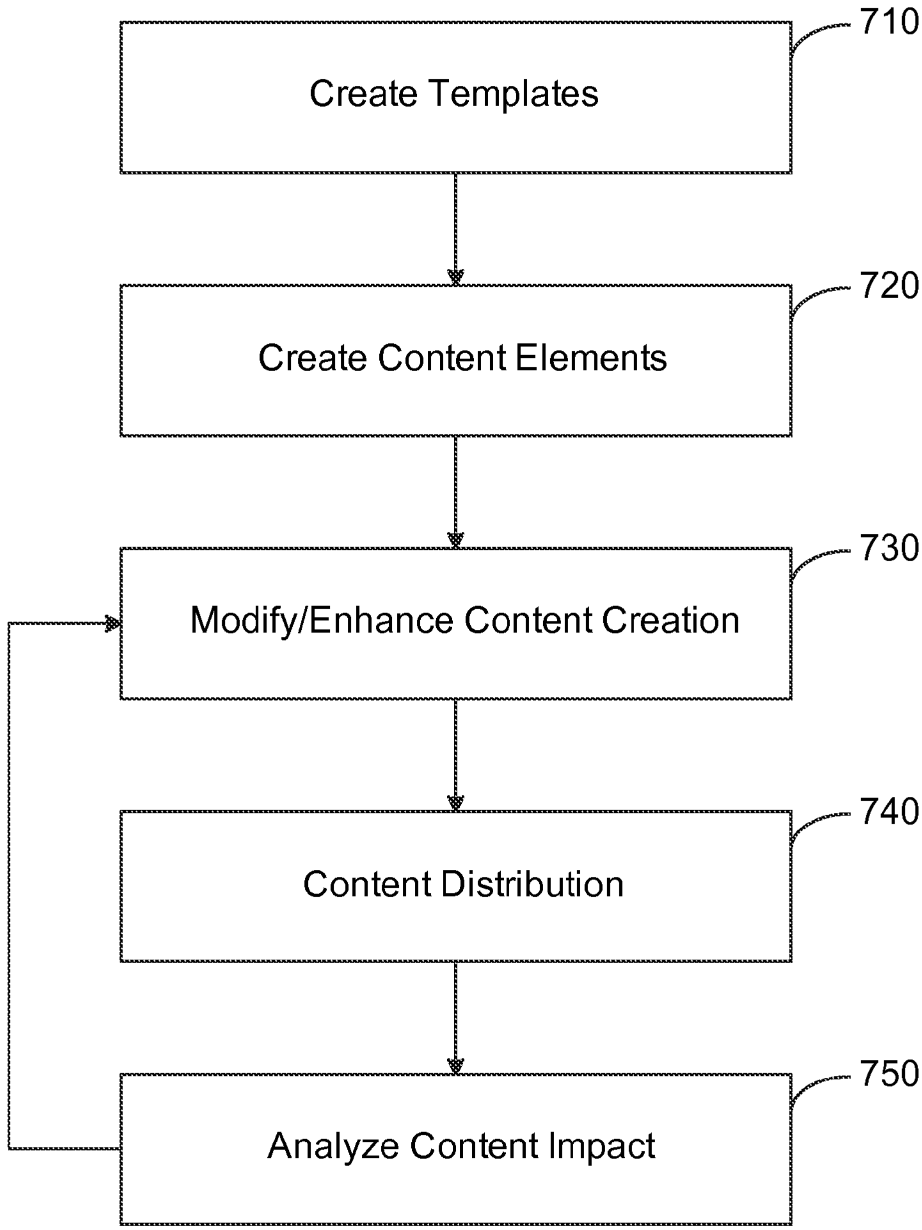

710
Create Templates
720
Create Content Elements
730
Modify/Enhance Content Creation
740
Content Distribution
750
Analyze Content Impact

FIG. 7

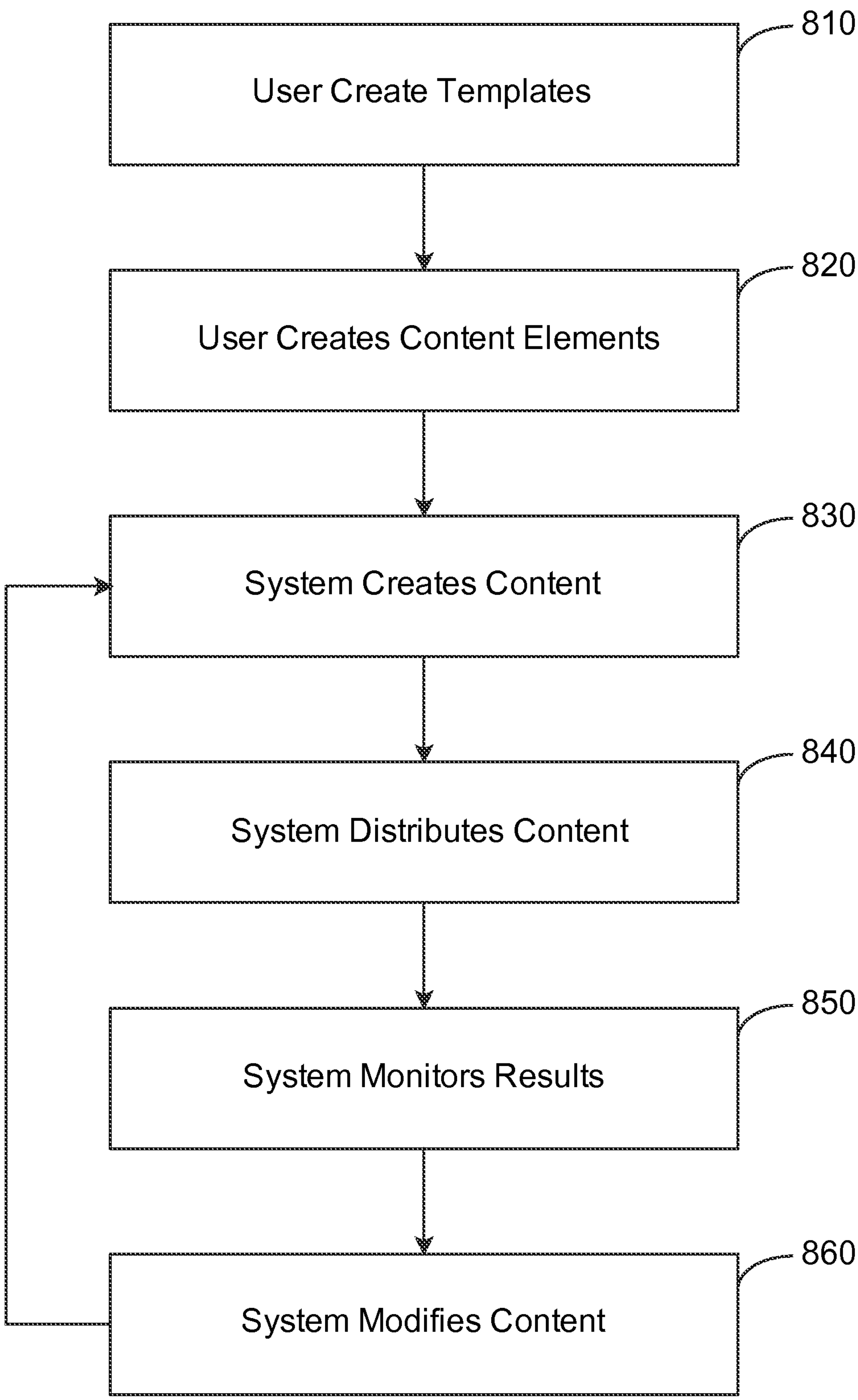

User Create Templates
810
User Creates Content Elements
820
System Creates Content
830
System Distributes Content
840
System Monitors Results
850
System Modifies Content
860

FIG. 8

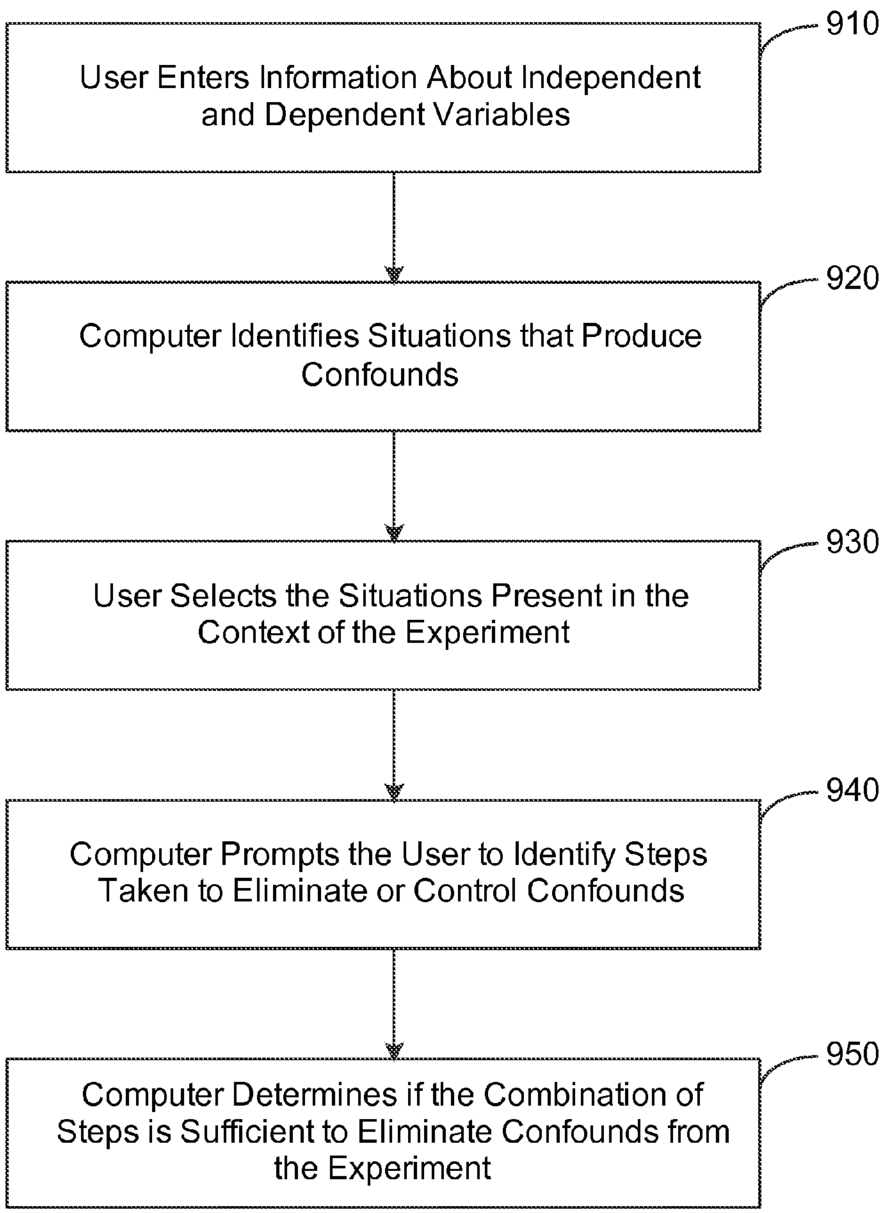

910
User Enters Information About Independent and Dependent Variables
920
Computer Identifies Situations that Produce Confounds
930
User Selects the Situations Present in the Context of the Experiment
940
Computer Prompts the User to Identify Steps Taken to Eliminate or Control Confounds
950
Computer Determines if the Combination of Steps is Sufficient to Eliminate Confounds from the Experiment

FIG. 9

SYSTEMS AND METHODS FOR DESIGNING EXPERIMENTS

FIELD OF THE INVENTION

[0001] The present invention relates to methods and systems for designing true experiments.

BACKGROUND

[0002] Experiments are typically conducted to determine empirically if there are relationships between two or more variables. An experiment typically begins with the formation of one or more hypotheses positing that there is a relationship between one or more independent variables and one or more dependent variables. For example, a researcher at a pharmaceutical company might formulate a hypothesis that the amount of a new drug that patients take will be related to the blood pressure of patients. Independent variables are the variables defined or manipulated by the experimenter during an experiment (e.g., the amount and/or frequency of a drug administered to patients). Dependent variables are the variables posited to depend on the value of the independent variable (e.g., the blood pressure of patients). The experimenter then conducts an experiment to determine if there is indeed a relationship between the independent and dependent variables (e.g., if the amount of a drug patients receive is related to the blood pressure of patients).

[0003] Confounding variables (things that vary systematically with the levels of the independent variable) may also influence the dependent variable. These confounding variables are not of primary interest in the experiment, yet can influence the dependent variables. Some examples of confounding variables include regression to the mean, order effects, floor-effects, ceiling effects, Hawthorne effects, and demand characteristics. Confounding variables make it impossible to know which factor (variable) caused any observed change in the dependent variable(s). And thus, the existence of confounding variables that are not properly controlled during the experiment renders it impossible to make statistical inferences about causal relationships between the independent and dependent variables. Various types of experiments may be distinguished by the manner and degree to which they are able to reduce or eliminate the effects of confounding variables. The term "true experiment" denotes an experiment in which:

[0004] 1. There are at least two levels of an independent variable.

[0005] 2. Samples are randomly assigned to levels of the independent variable. That is, each sample in the experiment is equally likely to be assigned to levels of the independent variable.

[0006] 3. There is some method of controlling for or eliminating confounds.

[0007] Experiments that lack any of the above three characteristics are not true experiments, and are often referred to as quasi-experiments or correlational designs. Only true experiments allow statistical inferences to be drawn regarding the causal relationships between independent and dependent variables. Quasi-experiments and correlational designs may allow relationships between independent and dependent variables to be established, but it is not possible to determine whether those relationships are causal. Various types of experimental designs (including true experiments) have been described, for example, in Campbell, D. T., & Stanley, J. C. (1963) *Experimental and quasi-experimental designs for research,* Chicago: Rand McNally. Data produced by a true experiment are substantially unaffected by confounding variables. However, the complexity of designing of a true experiment that appropriately controls or eliminates confounding variables may be significant.

[0008] It is also desirable to design experiments that have a sufficient degree of internal and external validity. Internal validity refers to the confidence that the independent variables caused any observed difference in the dependent variables. External validity refers to the confidence that the observed relationship between the independent and dependent variable in the experiment will apply to settings or situations outside of the settings of the experiment. Designing a true experiment having sufficient internal and external validity may be daunting for investigators who have only a limited knowledge of the statistical and experimental design principles. Systems and methods that provide investigators with a simplified approach to designing true experiments are desirable.

SUMMARY OF THE INVENTION

[0009] The present invention is directed to systems and methods for designing experiments. One embodiment of the invention involves a method for designing an experiment using a computer to determine whether the experiment is a true experiment.

[0010] According to various approaches, the computer may select one or more independent variables of the experiment and/or may select one or more dependent variables. The computer may automatically form one or more control groups of the experiment and/or one or more treatment groups of the experiment, including automatically randomizing the treatment or control groups. In some implementations, the computer may apply techniques (for example, blocking and counterbalancing) to reduce effects of one or more confounding variables.

[0011] According to other approaches, the computer may assist the user in various steps involving the experiment. For example, the computer may assist the user in selection of one or more independent variables and/or one or more dependent variables. The computer may assist the user in forming at least one of a control group and a treatment group. The computer may assist the user in randomizing samples to control and treatment groups and may alternatively or additionally apply techniques to reduce effects of one or more confounding variables of the experiment.

[0012] Another aspect of the invention involves performing the experiment. The computer may automatically run the experiment or may perform various functions to assist the user in running the experiment.

[0013] Another aspect of the invention is directed to analyzing results of the true experiment. Some implementations allow for the analysis to be performed automatically by the computer. In other implementations, the computer assists the user in analyzing the results of the experiment.

[0014] Another embodiment of the invention is directed to system for experimental design, the system including a design processor configured to determine whether an experiment is a true experiment. In some implementations, the design processor may be configured to select at least one of an independent variable and a dependent variable of the experiment. The design processor may be configured to form at least one of a control group and a treatment group of the experiment, including performing randomizing and blocking.

[0015] In some implementations, the system may assist the user in various functions associated with the experiment. In these implementations, the system includes a user interface configured to accept input from a user. The design processor may be configured to assist the user in selection of at least one of an independent variable and a dependent variable of the experiment using the user input. The design processor may be configured to assist the user in selection of at least one of a control group and a treatment group of the experiment based on the user input and may also assist the user in randomizing the groups and in applying blocking to reduce effects of one or more confounding variables of the experiment based on the user input.

[0016] According to another aspect of the invention, the system may include a deployment unit configured to run the experiment and/or an analysis unit configured to analyze results of the experiment. Deployment and/or analysis of the experiment may be performed automatically by the system or using input from a user.

[0017] In one implementation, the experiment comprises a digital signage experiment. In another implementation, the experiment involves an advertisement.

[0018] The above summary of the present invention is not intended to describe each embodiment or every implementation of the present invention. Advantages and attainments, together with a more complete understanding of the invention, will become apparent and appreciated by referring to the following detailed description and claims taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. **1** illustrates elements needed for a true experiment;

[0020] FIG. **2**A is a block diagram of a digital signage system that may incorporate the capability for designing true experiments in accordance with embodiments of the invention;

[0021] FIG. **2**B is a block diagram of a system for designing true experiments in accordance with embodiments of the invention;

[0022] FIG. **3** is a flowchart illustrating a method that includes the design of a true experiment in accordance with embodiments of the invention;

[0023] FIGS. **4**A-**4**C are flowcharts of a method incorporating designing experiments for digital signage implementations in accordance with embodiments of the invention;

[0024] FIG. **5** illustrates an exemplary layout for a digital signage display, including a weather/news panel, store logo, text crawl and area for video advertisements that may be implemented in accordance with embodiments of the invention;

[0025] FIG. **6** conceptually illustrates the functionality of a semi-automatic digital signage system in accordance with embodiments of the invention;

[0026] FIG. **7** illustrates the process flow of creating and deploying content using the components and functionality of a digital signage system in accordance with embodiments of the invention;

[0027] FIG. **8** is a flowchart illustrating an exemplary implementation of a digital signage system for a sporting goods retailer in accordance with an embodiment of the invention; and

[0028] FIG. **9** is a flowchart illustrating a method of determining if an experimental design eliminates confounds from the experiment in accordance with embodiments of the invention.

[0029] While the invention is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It is to be understood, however, that the intention is not to limit the invention to the particular embodiments described. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF VARIOUS EMBODIMENTS

[0030] In the following description of the illustrated embodiments, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration, various embodiments in which the invention may be practiced. It is to be understood that the embodiments may be utilized and structural changes may be made without departing from the scope of the present invention.

[0031] The present invention is directed to methods and systems that use a computer to determine whether the design of an experiment is a true experiment. The elements needed for a true experiment are illustrated in FIG. **1**. A true experiment includes development of a hypothesis or objective. Dependent and independent variables are identified, and at least two levels of an independent variable are used. Samples are randomly assigned to levels of the independent variable. There is some kind of method for controlling for or eliminating confounding variables. If all of these elements are appropriately applied, the experiment produces results that can be used to make statistical inferences about the relationship between the dependent and independent variables. Methods and systems described herein allow a user who is unsophisticated in the complexities of true experimental design to design and deploy an experiment that produces substantially confound-free results and can be used to determine and quantify any causal relationship between independent and dependent variables.

[0032] A true experiment has at least two levels of an independent variable. As described herein, some embodiments of the invention provide methods and systems that assist users in choosing independent variables for the experiment and in balancing between internal and external validity. For example, with respect to threats to internal validity, the methods and systems of the present invention assist the user through the process of identifying threats to internal validity, and may suggest and/or automate methods of controlling these threats, such as through counterbalancing and/or blocking. Some embodiments herein assist the user and/or automate the process of assigning samples randomly to groups so that each sample in an experiment is equally likely to be assigned to levels of the independent variable. In some configurations, the randomization, counterbalancing and/or blocking may be automatically performed. The system may select, or may assist the user in selecting, independent variables (or levels of independent variables) and dependent variables based factors associated with internal and/or external validity.

[0033] In yet other embodiments, the methods and systems of the present invention may be used to evaluate previously designed or conducted experiments. In these embodiments, based on input from the user regarding how an experiment was previously designed or conducted, the system determines if the experiment was indeed a true experiment (as opposed to a quasi-experiment or correlational study) and/or identifies the existence of confounds in the experiment. In some implementations, the approaches of the present invention may be used to determine the internal and/or external validity of an experimental design.

[0034] In some embodiments, the computer may operate in a semi-automatic mode, wherein the user is led by the computer through one or more interactive sessions to design, deploy, and/or analyze data acquired from a true experiment. In other embodiments, the computer is programmed to operate fully automatically without user interaction. In a fully automatic mode, a computer-based system may perform one or more of designing the experiment, deploying the experiment, acquiring data produced by the experiment, analyzing the data, determining internal validity of the experiment, determining external validity of the experiment, and/or modifying or implementing one or more processes based on the analysis. In yet other embodiments, the system may perform one or more of the steps described above semi-automatically and may perform another one or more of the steps fully automatically. The computer-based approaches to experimental design are described herein based on a computerized signage information system. The present invention is not limited, however, to the fields of communications systems or signage. The approaches of the present invention may be applied to the design of a true experiment regardless of the field of interest. For example, the methods and systems described herein may be applied to the design of experiments for any number of subject areas, including, but not limited to, biology, chemistry, linguistics, medicine, cognitive sciences, social sciences, education, economics, and/or other scientific fields. The examples are described in the context of a digital signage information system to allow the reader to develop an understanding of the principles of the invention which generally span all fields of scientific endeavor.

[0035] FIG. **2**A is a block diagram of a digital signage system (DSS) that may incorporate the capability for designing true experiments in accordance with embodiments of the invention. The block diagram of FIG. **2**A illustrates one configuration of a DSS divided into functional blocks. Those skilled in the art will appreciate that the DSS may be alternatively illustrated using different function blocks and that various components of the DSS may be implemented as hardware, software, firmware, or any combination of hardware, software and firmware.

[0036] The DSS illustrated in FIG. **2**A is a computerized system configured to present informational content via audio, visual, and/or other media formats. The DSS may include functionality to automatically or semi-automatically generate playlists, which provide a list of the information content to be presented, and schedules, which define an order for the presentation of the content. In a semi-automatic mode, a user may access a DSS control processor **205** via an interactive user interface **210**. Assisted by the DSS control processor **205**, the user may identify content to be presented and generate playlists and schedules that control the timing and order of presentations on one or more DSS players **215**. Each player **215** presents content to recipients according to a playlist and schedule developed for the player. The informational content may comprise graphics, text, video clips, still images, audio clips, web pages, and/or any combination of video and/or audio content, for example.

[0037] In some implementations, after a playlist and schedule are developed, the DSS control processor **205** determines the content required for the playlist, downloads the content from a content server, and transfers the content along with the playlist and schedule to a player controller **220** that distributes content to the players **215**. Although FIG. **2**A shows only one player controller **220**, multiple player controllers may be coupled to a single DSS control processor **205**. Each player controller **220** may control a single player **215** or multiple players **215**. The content and/or the playlists and schedules may be transferred from the DSS control processor **205** to the one or more player controllers **220** in a compressed format with appropriate addressing providing information identifying the player **215** for which the content/playlist/schedule is intended. In some applications, the players **215** may be distributed in stores and the content presented on the players **215** may be advertisements.

[0038] In other implementations, the DSS control processor **205** may transfer only the playlists and schedules to the player controller **220**. If the content is not resident on the player controller **220**, the player controller **220** may access content storage **225** to acquire the content to be presented. In some scenarios, one or more of the various components of the DSS system, including the content storage **225**, may be accessible via a network connection, such as an intranet or Internet connection. The player controller **220** may assemble the desired content, or otherwise facilitate display of the desired content on the players according to the playlist and schedule. The playlists, schedules, and/or content presented on the players **215** can be modified periodically or as desired by the user through the player controller **220**, or through the DSS control processor **205**, for example.

[0039] In some implementations, the DSS control processor **205** facilitates the development and/or formatting of a program of content to be played on a player. For example, the DSS control processor **205** may facilitate formatting of an audiovisual program through the use of a template. The template includes formatting constraints and/or rules that are applied in the development of an audiovisual program to be presented. For example, the template may include rules associated with the portions of the screen used for certain types of content, what type of content can be played in each segment, and in what sequence, font size, and/or other constraints or rules applicable to the display of the program. A separate set of rules and/or constraints may be desirable for each display configuration. In some embodiments, formatting a program for different displays may be performed automatically by the DSS control processor **205**.

[0040] In some embodiments, the DSS may create templates, generate content, select content, assemble programs, and/or format programs to be displayed based on information acquired through research and experimentation in the area of cognitive sciences. Cognitive science seeks to understand the mechanisms of human perception. The disciplines of cognitive and vision sciences have generated a vast knowledge base regarding how human perceptual systems process information, the mechanisms that underlie attention, how the human brain stores and represents information in memory, and the cognitive basis of language and problem solving. Application of the cognitive sciences to content design, layout, formatting, and/or content presentation yields information that is easily processed by human perceptual systems, is easy to understand, and is easily stored in human memory. Knowledge acquired from the cognitive sciences and stored in a cognitive sciences database **230** may be used automatically or semi-automatically to inform one or more processes of the DSS including creation of templates, content design, selection of content, distribution of content, assembly of programs, and/or formatting of programs for display. The cognitive sciences database **230** used in conjunction with the programming of the DSS yields advertisements or other digital signage programs that are enhanced by the teachings of cognitive science, while relieving the system user from needing specific training in the field.

[0041] In development of a digital signage program, e.g., ad campaign or the like, the DSS control processor **205** may guide a user through various processes that are enhanced using knowledge acquired through the cognitive sciences. For example, information stored in the cognitive sciences database **230** may be applied to the choice of templates to produce an optimal program layout and/or to the selection of content, such as whether content elements should be graphical, text, involve movement, color, size, and/or to the implementation of other aspects of program development.

[0042] The DSS may include the capability for designing alternative versions of a digital signage program to accommodate diverse display types and viewing conditions. Display technology is diverse and there are large differences in the types of displays used to present content on a digital signage network. For example, the size, shape, brightness, and viewing conditions will vary greatly across a digital signage network (e.g., some displays will be small, flexible and non-rectilinear, whereas others will be standard large format Liquid Crystal Display (LCD) and plasma displays). The variation in display types and viewing conditions means that any single version of a piece of content will not be optimal for all the displays across a network. In order to overcome this problem, it may be necessary to generate versions of each piece of content for each display type and viewing environment, and to selectively distribute these versions of content to their corresponding screens in the network. However, it is not realistic to expect content designers to have such detailed knowledge of the display types and viewing conditions across a large DSS network. Furthermore, even if such content designers had such detailed knowledge, it would be time-consuming to manually create versions of content for each display and to manually schedule the content to play on each corresponding display at the appropriate time.

[0043] The DSS may include a data acquisition unit **235** for collecting data used to improve the effectiveness of deployed content. The data acquisition unit **235** allows distribution factors that underlie the effectiveness of digital signage networks to be continuously gathered in real-time during deployment of content. The information acquired can facilitate continuous improvement in content effectiveness of the DSS as well as improvement of individual versions of content pieces. Real-time data may be used to learn what sensor or sales events should trigger the display of specific types of content, for example.

[0044] Individual pieces of content in any content program each have a specific goal (e.g., to sell a specific product). It is usually the case that there is variability in the value of each goal to the user of the digital signage network. For example, there may be variability in the profit margin and inventory level for each product which factor into the value of the goal for the product. The value of achieving each goal continuously changes during the time a digital signage program is deployed. For example, the inventory level of a product may change, thus affecting the goal for sales of the product.

[0045] Enhancing the effectiveness of a DSS as a whole, involves 1) accurate prediction of the impact of deploying a digital signage program on the goal associated with the digital signage program, and 2) continuously changing the distribution patterns (timing, frequency, and location) of individual pieces of content as the value of each individual goal corresponding to the pieces of content change. In many cases, it is unfeasible for users of the DSS to predict the impact of deploying content and to manually change content distribution patterns based on continuously changing values of goals associated with each piece of content. The DSS provides the functionality to predict the impact of digital signage programs and to alter the distribution of content based on the predictions.

[0046] As previously stated, content is displayed on the players **215** with the goal of affecting human behavior (e.g., to impact purchasing behavior). However, prior digital signage systems are unable to demonstrate a cause-and-effect relationship between signage content and human behavior or to measure the strength of the cause and effect relationship. This difficulty arises because the methods by which content is delivered across current digital signage networks does not support the determination of whether any measured change in human behavior was caused by signage content or the result of some confounding factors (e.g., change in weather, change in general demand for the product, change in price of the product). The only way to decisively determine cause-and-effect relationships between signage content and human behavior is to conduct a true experiment during which signage content is systematically manipulated using complex experimental designs, and the effects of those manipulations on human behavior are carefully measured. Manually conducting such experiments is time consuming and requires significant knowledge and training in the scientific method of how to design true experiments. The users of digital signage systems may not have sufficient training to understand how to design a true experiment to acquire confound-free results.

[0047] The DSS may include components that provide the capability to design, deploy, and/or analyze data acquired from true experiments. As previously discussed, the components providing this functionality may be incorporated into a DSS or may be implemented by other types of systems. Components that may be used in the design, deployment, and/or analysis of true experiments, regardless of the particular type of system in which they are implemented, are set forth separately in the block diagram of FIG. **2**B. A system according to the present invention may include one or more of the features, structures, methods, or combinations thereof described herein. For example, a system may be implemented to include one or more of the advantageous features and/or processes illustrated in FIGS. **2**A or **2**B. It is intended that such a system need not include all of the features described herein, but may be implemented to include selected features that provide for useful structures and/or functionality.

[0048] FIG. **2**B illustrates an experiment design system (EDS) including experiment design processor that is configured to ensure the design of a true experiment. As previously discussed, the experiment design processor **240** may be configured to operate fully automatically or semi-automatically with user interaction. In semi-automatic mode, the experiment design processor **240** may lead a user through various interactive sessions conducted via the user interface **210** to design a true experiment. In such a process, the experiment design processor **240** ensures the design of a true experiment that produces confound-free data. Thus, a user is able to rely on the programming of the experiment design processor **240** and is not required to have knowledge or experience in designing true experiments. The EDS may comprise only an experiment design processor **240**, or may include additional elements such as an experiment deployment unit **245**, a data acquisition unit **235**, and data analysis unit **250**.

[0049] The experiment design processor **240** may, automatically or semi-automatically, develop an objective or hypothesis for the experiment, identify independent and dependent variables of the experiment, form control and treatment groups applying appropriate randomization, counterbalancing and/or blocking. In the context of a DSS, for example, the experimental objective may be to evaluate the effectiveness of a content element in an ad campaign promoting sales of a certain product. The independent variable(s) may be associated with some aspect of the display of the content element. The dependent variable(s) may be associated with an increase in sales of the product.

[0050] The experiment design processor **240** may form appropriate treatment and control groups including the selection of various venues of the DSS system where the experimental content and control content is to be displayed. Presentation of the experimental content, including content format, schedule, presentation location, and/or other factors that may produce confounds into the experimental process, are controlled by the experiment design processor **240**. The experiment design processor **240** may ensure adequate randomization, counterbalancing, and blocking of the control and treatment groups to achieve experimental results that are confound-free. Design of the experiment in the context of the DSS system may involve, for example, generating appropriate playlists and schedules for the presentation of content to be tested via the experiment, and may also involve generating playlists and schedules for presentation of control content.

[0051] The EDS may further include an experiment deployment unit **245**. The experiment deployment unit **245** is configured to facilitate deployment of the experiment. In the context of the exemplary DSS system, the experiment deployment unit **245** formats the experimental content and the control group content for various player configurations and facilitates the transfer of the experimental content and the control content to the player controller **220** for presentation on players **215** as specified by the playlists and schedules.

[0052] The data acquisition unit **235** may be configured to collect experimental data from the control and treatment groups. The data acquisition unit **235** may perform or facilitate acquisition of data associated with the experiment via any means. For example, in the context of the exemplary DSS, the data acquisition unit **235** may be coupled to various sensor or data acquisition devices **262**, **264**, **266** that gather information including product movement, product sales, customer actions or reactions, and/or other information. Sensors **262** may be used to detect, for example, if a customer picks up the product, or if a customer is in the vicinity of the display when the content is displayed. Sales may be determined based on information acquired by a point of sales (POS) system **264**. Other devices **266** that measure the dependent variable may also be used. Changes in inventory levels of a product may be available via an inventory control system. Customer reactions may be acquired via questionnaires. If the conducted experiment is a true experiment, the data acquired by the data acquisition unit **235** is substantially confound-free.

[0053] The data acquisition unit **235** may be coupled to a data analysis module **250** that is configured to analyze the experimental data collected by the data acquisition unit **235**. The data analysis module **250** may determine and/or quantify cause and effect relationships between the independent and dependent variables of the experiment. For the illustrated DSS, the results of the analysis may be used to determine if the content is effective at influencing product sales.

[0054] The results of the analysis may be additionally or alternatively used to implement or modify various processes. For example, if the content was effective at influencing product sales, an advertisement campaign may be developed incorporating the content. A value may be assigned to the content by a content valuation process **272** based on the effectiveness of increasing sales. An advertiser using the content may be invoiced by a billing unit **274** according the value of the content. The data analysis module **250** may also provide information to inventory control **276**. Additionally, the data analysis module **250** may provide information to a prediction unit **278** that generates a prediction of sales when the advertising campaign is deployed. The prediction unit **278** may additionally or alternatively predict the product inventory needed to support the sales generated by the advertisement campaign.

[0055] The flowchart illustrated in FIG. **3** provides an overview of a method that may be implemented by the DSS (FIG. 2A) and/or the EDS (FIG. 2B) in accordance with embodiments of the invention. The method includes design **310** and performance **320** of a true experiment. Data produced by the experiment are collected **330** and analyzed **340**. One or more processes may be modified or implemented **350** based on the data analysis.

[0056] The flowcharts of FIGS. **4**A-**4**C provide a more specific example of these processes in the context of digital signage in accordance with embodiments of the invention. In this example, the objective of the experiment is to determine the effect of a video advertisement for a DSS incorporating Content A on sales of Product X. For example, Content A may be an advertisement featuring a video of an actor, athlete, or other famous person. The content to be tested (Content A) is identified **402** and control content **404** is selected. A video advertisement incorporating Content A is produced **406** using template rules stored in local memory. The template rules may also be applied to produce video content to be used for the control group. The template rules may be used to provide a structure for arranging the layout of content on the display. In some cases, the template rules are based on information derived from the cognitive sciences. An exemplary layout for a digital signage display including a weather/news panel, store logo, text crawl, and area for video advertisements is illustrated in FIG. **5**.

[0057] Playlists and schedules are specified **412**, **414** for the video advertisement incorporating Content A and the control content. Venues for the advertisement and the control content are selected **416**, **418**. For example, the venues of the advertisement and control content may be restaurants, stores, shopping malls, or other locations. Development **412**, **414** of the playlists and schedules, and selection **416**, **418** of venues is performed using appropriate randomization and blocking to exclude or reduce confounding variables in the experimental results.

[0058] The advertisement and control content may be deployed to a number of venues, each venue having a particular set of viewing characteristics. For example, venues may vary with respect to display size, display shape, viewing distance, ambient lighting, noise level, and other viewing conditions. The advertisement is adjusted **422** to conform to the attributes of each display on which the advertisement it deployed. Similar adjustments are performed **424** for the control content. The advertisement and the control content are shown **426**, **428** according to their respective playlists and schedules.

[0059] Data may be collected at each venue before, during and after display of the advertisement and/or the control content. The data may be collected via sensors, point of sale terminals, inventory control systems, and/or other input devices. For example, viewer presence in the vicinity of the display during presentation of the advertisement may be detected. The number of times the advertisement and control content was displayed **432**, **434** or viewed **436**, **438** may be detected. Viewer motion, eye movements, and/or interaction with Product X may be sensed **442**. The volume and timing of sales of Product X may be determined **444** from point of sales terminals. Viewer responses to the advertisement may be acquired via questionnaires. For example, the questionnaires may be used to determine if the viewers reported a generally positive or generally negative reaction to the advertisement. Before and after questionnaires may be used to determine if the advertisement changed the consumer's level of familiarity with Product X. Changes in inventory levels of product X may be determined.

[0060] The collected data may be analyzed **446** to determine causal relationships between display of the advertisement containing Content A and sales of Product X. Based on the analysis, a value may be assigned **448** to Content A. If Content A is successful at increasing sales, an advertisement campaign may be generated **452** incorporating Content A. The return on investment (ROI) for the advertising campaign may be determined **454**. The business providing the advertisement campaign or the systems for presenting the advertisement campaign may bill **456** their customers according to the value of Content A or predicted ROI as determined by the experiment. The sellers of Product X may predict inventory requirements **458** for Product X during an advertisement campaign incorporating Content A based on the results of the experiment. The system may iteratively modify **462** one or more processes based on the experimental results.

[0061] FIG. **5** illustrates an exemplary layout for a digital signage display that may be controlled by the DSS of the present invention. The digital signage display may be configured to include a number of areas such as a weather/news panel, a store logo graphic, text crawl, and area for video advertisements.

[0062] FIG. **6** conceptually illustrates the functionality of a semi-automatic DSS, such as the system illustrated in FIG. **2**A, in accordance with embodiments of the invention. The DSS may functionally be broadly grouped into four areas. The first functional area illustrated in FIG. **6** provides for the application of cognitive and vision sciences **610** to digital signage. Programming tools are provided that allow content designers without advanced training in the visual and cognitive sciences to apply principles from these disciplines during the content creation process, in order to improve content effectiveness. The system prompts the user to input both the goal and the intended message (the critical information) for each piece of content. The user is assisted in the identification of key attributes across the digital signage network that have implications for content design. The system guides the user through the process of applying the cognitive and visual sciences to design content based on the goals and key digital signage network attributes. For example, the system would help users choose the templates (i.e., best layout) and the elements (e.g., whether elements should be graphical, text; involve movement, color, size, etc.) to display on the signs.

[0063] Another functional component of the DSS provides content effectiveness measurement **620**. The programming of the DSS allows the user with little or no training or skills in conducting experiments to generate complex experimental designs. The experimental designs may be used to investigate the content design and distribution factors that underlie effective digital signage networks, and to measure the impact of content on human behavior. Users are assisted in identifying the independent variables likely to be critical to content effectiveness and the dependent variables corresponding to the independent variables. An appropriate experimental design is generated by the system, including identifying appropriate control and experimental conditions, appropriate blocking, counterbalancing, and randomization, to determine the strength of any causal relationship among and between those independent and dependent variables. The experiment is performed, data are collected via sensors and/or other processes, and is the data are analyzed. Results of the experiment are may be used by various other components of the system and/or may be reported to users.

[0064] The use of true experiments provides complex and rigorous methods to deliver content that allows the collection of very clear (confound-free) data. This is in contrast with the approach of using quasi-experiments which require extremely complex analysis methods (i.e., behavioral analytics) to analyze and use data that are fraught with confounds.

[0065] The DSS provides automated content design **630** that automatically generates new templates and applies transformations to existing elements. New templates and elements may be generated to improve the content effectiveness, and/or to create appropriate content to fulfill the needs of the experimental designs previously described. The tools provided by the DSS are capable of generating unique versions of pieces of content for each player in the system. The DSS system may prompt users to provide input or may use information supplied from other components regarding the network attributes and factors that underlie content effectiveness. Knowledge from the cognitive and visions sciences may be used to extrapolate, fill in, and otherwise explore the information space for the particular pieces of content the system aims to enhance. The functionality of the DSS provides the ability to generate completely new content that is not simply a reconfiguration of deployed templates or elements associated with deployed versions of content. That is, the DSS does not simply rely on the hybridization/blending of deployed templates and elements that data suggest are effective, although the system is capable of hybridization/blending.

[0066] The DSS system includes the functionality to distribute **640** different content pieces across a network of displays to enhance the system level (i.e., superordinate-level) goals. For example, content pieces may be distributed system-wide to coordinate the sales of different items, or to respond to different inventory levels (sales rates, profit margins) at different geographic locations.

[0067] The functional components **610-640** illustrated in FIG. **6** are individually useful. However, when the components **610-640** are combined into a unified system, a number of other key benefits arise out of the combined system. Application of cognitive and vision sciences **610** allows users with little or no background in the cognitive and visual sciences to apply these disciplines in order to create more effective content. This functionality can be used in either a single or multi-screen environment. On a system-wide level, application of cognitive and vision sciences provides input and constraints for the automated content design system in order to tailor content on a screen-by screen basis. For example, if the average viewing distance is known for each network sign, then the component for applying the cognitive and visual sciences will determine the ideal font size for each sign, and this information will be used by the automated content design component to generate text with those font-size parameters. The system may suggest the key parameters that should be manipulated during the experiment process, and may provide the upper and lower bounds of those parameters.

[0068] Content effectiveness measurement **620** can operate in either a single or multi-screen environment to generate experimental designs and analyze data regarding the impact of content on any measurable human behavior. Content effectiveness measurement **620** can determine causal relationships between signage content and human behavior. In one example, it is possible to determine the precise financial value of content (and thus of the digital signage system) for any human behavior that can itself be assigned a precise value. The human behavior having the most obvious known value is purchasing behavior. However, through the system's ability to sense other human behaviors, users could assign dollar values to a wide variety of actions, such as eye movements, picking up products, reduction in wayfinding times, etc.

[0069] In another example, market researchers could test their hypotheses regarding what feature sets in products are most valuable by generating content describing different feature sets of the same product. By determining what content pieces are the most effective, it would be possible to make inferences regarding what feature sets are the most valuable to consumers.

[0070] On a system level, content effectiveness measurement **620** provides input to the automated content design component regarding the effectiveness of design parameters, which allows the automated content design component to continuously improve the effectiveness of deployed content. Further, continuously updated input can be provided to allow the content distribution component to predict the impact that specific content distribution patterns will have on a given goal-state.

[0071] Content distribution functionality **640** provides for continuous changes in the relative frequency with which individual pieces of content are presented across the network in order to attain or maximize a goal of the digital signage network. Changing the relative frequency involves increasing or decreasing the number of times individual pieces of content are shown on individual signs. All other content distribution factors, such as the versions of pieces of content that are shown on specific screens remain the same. For example, the system can decrease the frequency of presenting pieces of content corresponding to products that have lower inventory levels and increase the frequency of presenting content corresponding to products with higher inventory levels.

[0072] System wide, the content distribution component **640** can receive input from the content effectiveness measurement component **620**, and leverage that input to strategically distribute content on a screen-by-screen basis based on the predictions that arise out of the cause and effect information gathered by the content effectiveness measurement component.

[0073] FIG. **7** illustrates the process flow of creating and deploying content using the components and functionality of the DSS described above. During the first cycle, or initialization, the process uses data from outside the system to optimize the system goals. During subsequent cycles, the process may rely on data acquired by the system itself to modify and/or enhance the system goals. To elaborate, during the first cycle, the process illustrated in FIG. **7** uses prior knowledge from the cognitive and vision sciences to optimize goals; and subsequent cycles use cognitive and vision sciences and also results from real-time experimental data to optimize system goals. Thus, during initialization, the process uses a priori sources of data. During subsequent cycles no user-interaction is required. During the subsequent cycles, both a-priori and a-postiori data are used.

[0074] The process walks the user through a series of tools and scripts, and creates **710** a number of alternative templates that specify how categories of content elements might appear on the screen (e.g., the location, size, and orientation of elements such as text, graphics and videos). The tools and scripts suggest recommended templates by drawing on three sets of information: a) principles from the cognitive and visual sciences regarding effective display of information, b) the goals for the content (e.g., way-finding, advertising), and c) the known attributes of the digital signage network (e.g., size and shape of the different displays, different viewing distances, and viewer demographics across the network). For example, the tools and scripts might help a user determine whether an element should be represented graphically or via text. The tools and scripts might also help a user determine which of a large number of pre-defined templates are appropriate given the viewing conditions across the network, goals for the content, and if available, metrics regarding the types of templates that have been effective from previous campaigns.

[0075] The process walks the user through a series of tools and scripts to generate **720** the particular content elements that will later be placed within the templates created at block **710**. The individual content elements can include specific text messages, static images, animations, movie clips, sound bites, etc. Each element could have many variants, and software helps the user determine which elements of content can be combined within a template, the rules for how those elements can be combined, and the parameters on which the content elements can be manipulated during the content creation process. For example, it may be legal to change the color of a font during deployment, but not the color of the face of a famous person used in the template.

[0076] The software tools and scripts facilitate content generation by drawing on three sets of information: a) data regarding the types of content elements that were effective in previous campaigns, b) principles from the cognitive and visual sciences, and c) the known attributes of the digital signage network. After the content is created, in this example, user interaction is no longer necessary.

[0077] Content creation is enhanced **730**. The process may involve various constraints to combine elements and templates to create a number of versions of content. The first time through this process, the constraints will be based on: a) the factors previously used for used in creation of templates and content elements above, b) pre-programmed guidelines for how to combine elements and templates, c) goals for the piece of content being deployed, and d) the parameters of experimental design. On subsequent passes through this block, the process will also use effectiveness data to alter existing or create novel templates (through interpolation) and elements before creating new versions of content. Because each display in a network may have different attributes (e.g., different lighting levels, noise levels, shape, size, and mean viewing distances), a unique version of content may be created for each display in the network.

[0078] The content is distributed **740** across the digital signage network. Content distribution involves the determination of what, where, and when individual pieces of content are displayed in order to: a) allow cause-and-effect relationships between content and viewer behavior to be determined, b) enhance the system-level goals of the active signage network, and thus the overall network return on investment, c) allow accurate measurement of the effectiveness of specific templates and content elements.

[0079] The content distribution process allows versions of content to be distributed using appropriate blocking and counterbalancing procedures. Further, appropriate baseline control conditions are used for known attributes of the signs across the network, and versions of content are properly randomized for unknown factors. These algorithms determine the appropriate experimental design given the signage network attributes, e.g., the number of attributes, and the relations among the attributes. This functionality coordinates the playback requirements, such as the frequency and timing of playback and location of playback of individual pieces of content across the system.

[0080] Using sensor data, point of sale, inventory data, and/or other data in conjunction with the experimental procedures used to distribute content, the impact of content is calculated and analyzed **750**. To describe this step in terms of perceptual experiments, the effect-size of the content elements and templates is calculated. Effect size refers to the amount of variability in the data that any defined variable can explain. The process analyzes and predicts what content would be effective for a given attribute across the network. Also, co-occurrences of sensor data, content presentation, and movement towards the goal are detected. Therefore, it is possible to learn that some detected event, when paired with content, increases the direction towards the goal. These co-occurrences then become new digital signage network attributes. Content may be distributed in order to take advantage of co-occurrences of sensor data, content presentation, and movement towards the goal state.

[0081] The analysis performed at block **750** forms the basis of reporting return on investment (ROI), future content creation, and future content deployment. Inferential statistics may be conducted on the pre-identified dependent variables. From these inferential statistics, the system can calculate effect sizes and confidence in cause and effect relationships, including the effects of content elements, templates, and deployment.

[0082] FIG. **8** is a flowchart illustrating an exemplary implementation of the DSS system in accordance with an embodiment of the invention. The implementation involves a sporting goods retailer with 200 stores. The retailer desires to advertise four overstocked products and four products that are not overstocked but that have higher profit margins than the overstocked products. The super ordinate-level goal of the campaign is to maximize gross profit while eliminating excessive inventory of the overstocked items. That is, once the excessive inventory is eliminated, the goal will simply reduce to maintaining a balanced inventory at each store location.

[0083] Using cognitive and visual-science driven software, the signage manager of the retailer creates **810** a number of different templates that will be used to develop content for each of the eight product lines. These templates include layout of messages, color schemes, and/or other variables that make up the program. These templates can be used for each of the eight product lines, and are not specific to a single product. Additionally, pre-existing or stock templates are available for use during this phase.

[0084] After creating the base templates for this campaign, the signage manager creates **820** individual content elements that are needed to populate the templates. The individual elements are specific to the product lines being promoted, and include product branding and messages for given products. As in the template creation process, creation of individual elements is guided by software wizards using cognitive and visual-science driven software.

[0085] The templates are automatically populated **830** with the individual content elements to generate a number of different content packages for each of the eight products that the signage network is promoting. Potentially hundreds of differing versions of each content piece are created for each product line by merging elements with templates to accommodate varying signage attributes such as screen size or viewing distance.

[0086] Using pre-existing or learned knowledge about the signage network, content is distributed **840** by using algorithms that enable collection of success metrics for individual pieces of content. The content is distributed across the network in a way that ensures proper counterbalancing, blocking, and confound-free measurement can be made. Additionally, the deployment algorithm ensures that relevant content is sent to the appropriate signs in the network, considering network attributes, viewer demographics, and viewing conditions among others.

[0087] Point of sale and sensor data allow the impact of the various content packages to be monitored **850** and analyzed to determine what templates and content elements, and their combinations, are most effective for each screen on the network. From this information, cause and effect, as well as return on investment can be analyzed, enabling value-based billing. This example may determine whether across all 200 stores, the signage system itself was responsible for X % increase in profits and Y % decrease in excessive inventory. Exploratory data analysis generates new possible network attributes. For example, there is a spike in sales when customers pick up product X and when content Y is concurrently shown. On the next iteration, this new network attribute will be tested experimentally, not just measured from a correlation study. For example, the system may determine whether content pieces presented on X type screens is most effective using Y-type templates, and that the most effective content elements have XYZ properties.

[0088] Based on the effectiveness data, the system automatically generates **860** new templates, new content elements, and new combinations thereof. Again, using signage network attributes (both old and new), the software deploys these new pieces of content across the network.

[0089] During the remainder of the campaign, the processes described in blocks **830** through **860** are repeated, for example, without user interaction. The signage network manager is able to monitor the impact that the content has on sales at any given point during the campaign while the system automatically attempts to achieve the campaign goals.

[0090] Upon completion of this campaign, templates and elements that were manually or automatically generated during the campaign are available for future campaigns as well. Furthermore, the knowledge that was gained regarding the types of templates and elements that are effective for particular displays, demographics, or other factors, is used create and distribute content more effectively across the network during future campaigns.

[0091] Determination of whether an experiment is a true experiment can be performed proactively or retroactively with respect to running the experiment. According to some embodiments, a computer may be used to determine if an experiment that is yet to be performed is a true experiment. According to other embodiments, a computer may be used to determine if an experiment that was previously performed is a true experiment. According to the approach illustrated in FIG. **9**, the computer determines, based on information provided by the user, whether an experimental design eliminates or controls confounds. In this example, the user enters **910** information about the experiment, including the independent and dependent variables of the experiment. The computer identifies **920** situations that may produce confounds in the experiment. The user selects **930** the confound-producing situations identified by the computer that are present in the context of the experiment. The computer prompts **940** the user to identify steps taken to eliminate or control the identified confounds. The computer determines **950** if the combination of steps is sufficient to eliminate confounds in the experiment.

[0092] The foregoing description of the various embodiments of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. For example, embodiments of the present invention may be implemented in a wide variety of applications. It is intended that the scope of the invention be limited not by this detailed description, but rather by the claims appended hereto.

What is claimed is:

1. A digital signage system having a plurality of displays dispersed in multiple locations and one or more processors and memories, comprising:

an experiment design processor selecting test locations where experimental content and control content will be presented,

wherein the experiment design processor generates a playlist for the experimental content and the control content, wherein the experiment design processor randomizes the playlist such that schedule and location confounds are eliminated;

a player controller receiving the playlist and presenting the playlist on the players of the digital signage network at the test locations;

a data acquisition device collecting data regarding activities at the test locations;

an analysis module determines if the experimental content is effective based on the collected data.

2. The digital signage system of claim **1**, wherein the experiment design processor uses blocking of the experimental content and the control content to generate the playlist.

3. The digital signage system of claim **1**, wherein the experiment design processor uses counterbalancing of the experimental content and the control content to generate the playlist.

4. The digital signage system of claim **1**, wherein the experimental content comprises at least one of graphics, text, video clips, still images, audio clips, and web pages.

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